Phase I Project Summary

Firm: Orbital Technologies Corporation

Contract Number: NNX13CC35P

Project Title: Integrated Composite Rocket Nozzle Extension (ICRNE)

Purpose of the Research:

ORBITEC is developing the Integrated Composite Rocket Nozzle Extension (ICRNE) technology for upper stage engines and in-space propulsion systems. The ICRNE technology is an innovative method to join a high-temperature carbon composite nozzle extension to a regeneratively-cooled nozzle section that is made out of a high-strength metallic alloy. The ICRNE technology will allow composite materials to be directly integrated into a regeneratively-cooled nozzle section or thrust chamber, thereby eliminating the heavy bolted flange joint that is currently used. The resulting weight reduction will increase the thrust-to-weight ratio of the rocket engine. It will also eliminate the need for multiple seals in the bolted flange joints, improving reliability and safety. The purpose of the Phase I effort was to demonstrate the technical feasibility of the ICRNE technology through analysis and fabrication of test specimens.

Description of the Research Carried Out:

The design requirements for a prototype ICRNE unit were defined. The prototype ICRNE unit will be integrated into an existing rocket engine and demonstrated in a hot-fire test series during the follow-on Phase II effort. A preliminary design of the prototype ICRNE was developed, including: materials evaluation and selection; structural design; and thermal and structural analysis. A manufacturing plan to fabricate ICRNE test specimens in Phase I and the prototype ICRNE in Phase II was developed. Multiple test specimens were also manufactured and evaluated.

Research Findings/Results:

Preliminary design requirements for the prototype ICRNE unit were developed. An iterative design and analysis cycle identified the preferred materials to use in the prototype ICRNE and validated that the stress levels are acceptable. A manufacturing plan to fabricate test specimens in Phase I and the prototype ICRNE unit is Phase II was developed. Multiple test specimens were also fabricated during the Phase I effort. Some issues were encountered during fabrication of the test specimens, but the root cause of those issues was identified. Changes were made in the manufacturing process to eliminate these issues going forward.

Justification for Phase II Continuation:

The design, analysis, and experimental work performed during Phase I ICRNE project have demonstrated the technical feasibility of the ICRNE concept. The ICRNE concept is ideally suited for upper stage engines which utilize cryogenic propellants. This is a challenging application due to the mismatch of thermal expansion properties and the large thermal gradients present during operation. However, the multiple structural and thermal stress analyses performed during Phase I allowed the design of the prototype ICRNE unit to be refined and identify the required materials. Although some issues were encountered during the fabrication of the test specimens, the root cause was identified and the process was modified to eliminate the problems going forward. The proposed Phase II effort will build upon the knowledge gained during Phase I and culminate in the demonstration of a prototype ICRNE unit in a hot-fire test series.